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Westinghouse Owners Group - EPRI Meeting with the US NRC on ASIC Based Reactor Control & Protection System Replacement Modules for Westinghouse Designed Nuclear Units

November 12, 1996

Westinghouse Rockville Licensing Office
Rockville, MD

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AGENDA

Westinghouse Owners Group - NRC
Meeting on ASIC-Based Process
Protection System Card Replacement

Meeting Date: November 12, 1996

Meeting Time: 8:00 AM - 1:00 PM

Meeting Place: Westinghouse Rockville Licensing Office

Participants:
Mike Marino, ASIC Steering Committee Chairman, VP
Darrell Cooksey, Union Electric
Bob Queenan, Duke
Dennis Deardorf, SCE&G
Mike Murray, HL&P
Paul Travis, HL&P
Bob Cockrel, TU
Joe Naser, EPRI
Bob Sterdis, Westinghouse
Carl Vitalbo, Westinghouse
Ron Battle, ORNL

NRC: Jim Stewart
Jerry Mauck
Jerry Wermeil

Agenda:

8:00 AM - 1:00 PM

I.	Design Status	1 hr.
II.	Licensing Approach	1 hr.
III.	Elements of Licensing Strategy	1 hr.
IV.	Identification of Licensing Issues to be Addressed in Topical Report	2 hrs.

Objectives:

(1) Gain agreement with NRC on licensing approach (schedule, fees, topical content, SER, what will NRC review against).

(2) Gain agreement with NRC on licensing issues.

(3) Inform NRC of design status.

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DESIGN UPDATE

Figure 2-1 ASIC Block Diagram

ASICs CARD DIAGRAM

TOP SILK SCREEN LAYER

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TOP SILK SCREEN LAYER
TOP COMP. SIDE

7300A OPERATOR INTERFACE

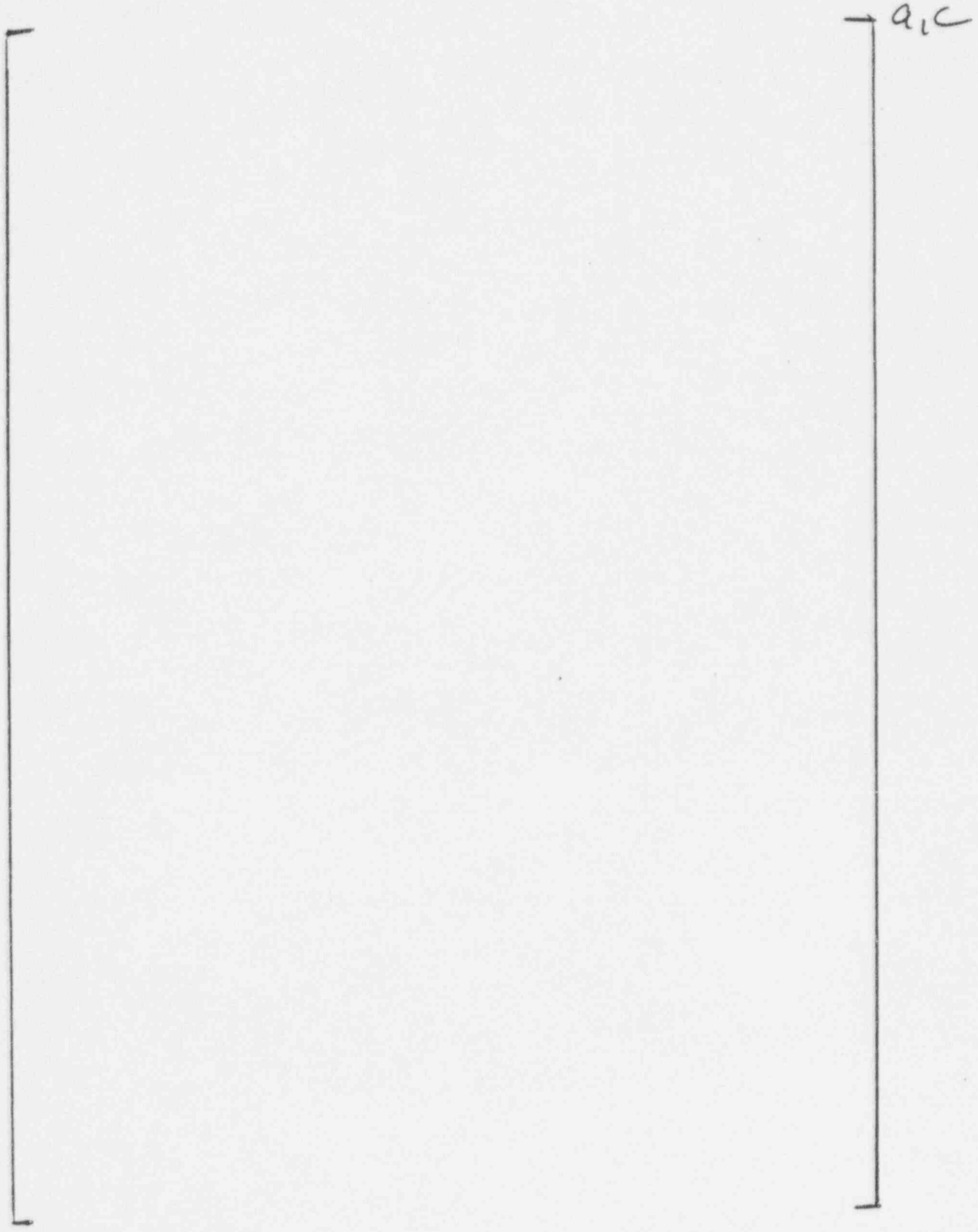


Figure 2-2 7300A OPERATOR INTERFACE

7300A CONTROLLER

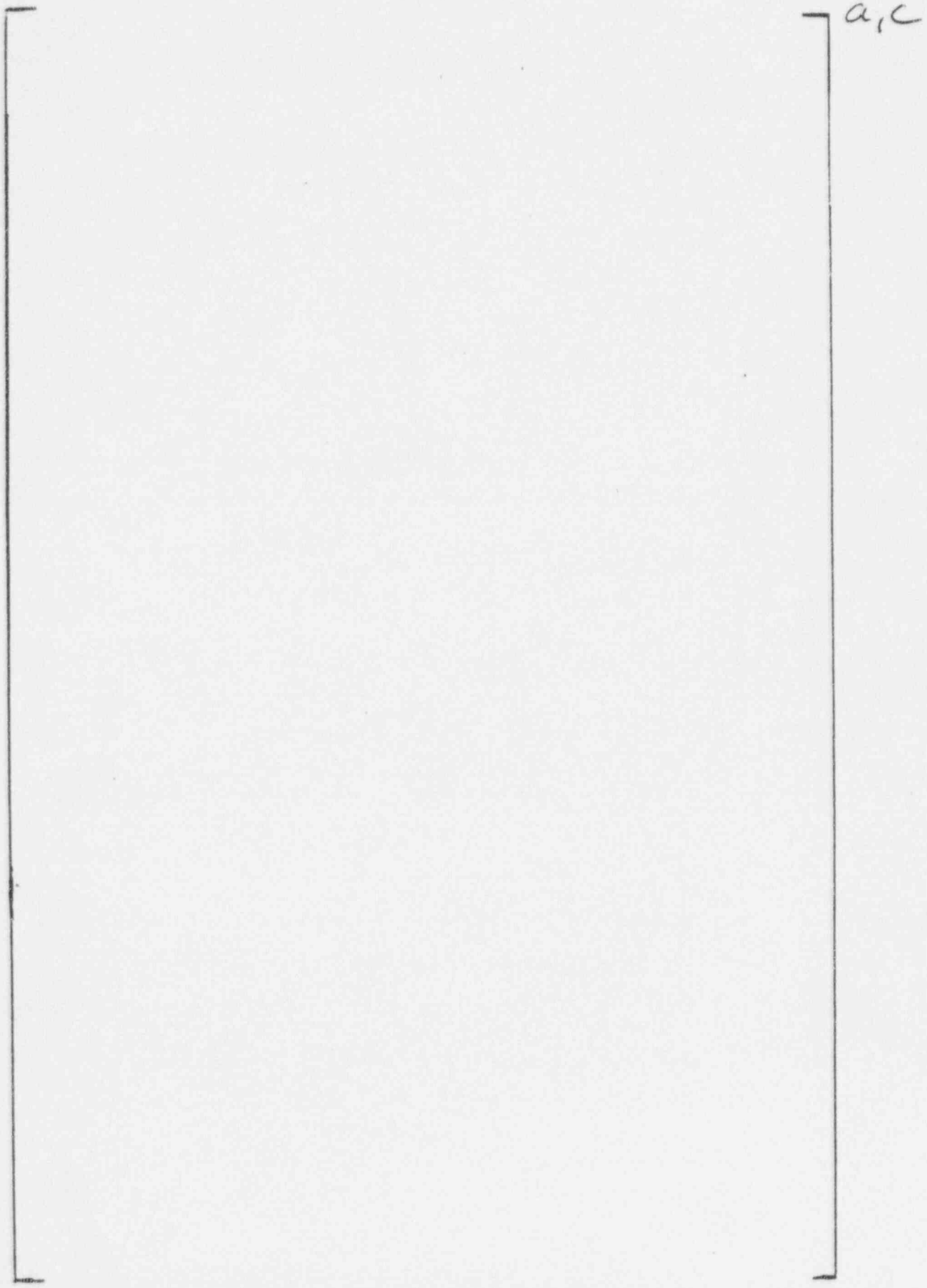


Figure 2-3 ASIC Controller

GENERAL ALARM CIRCUIT

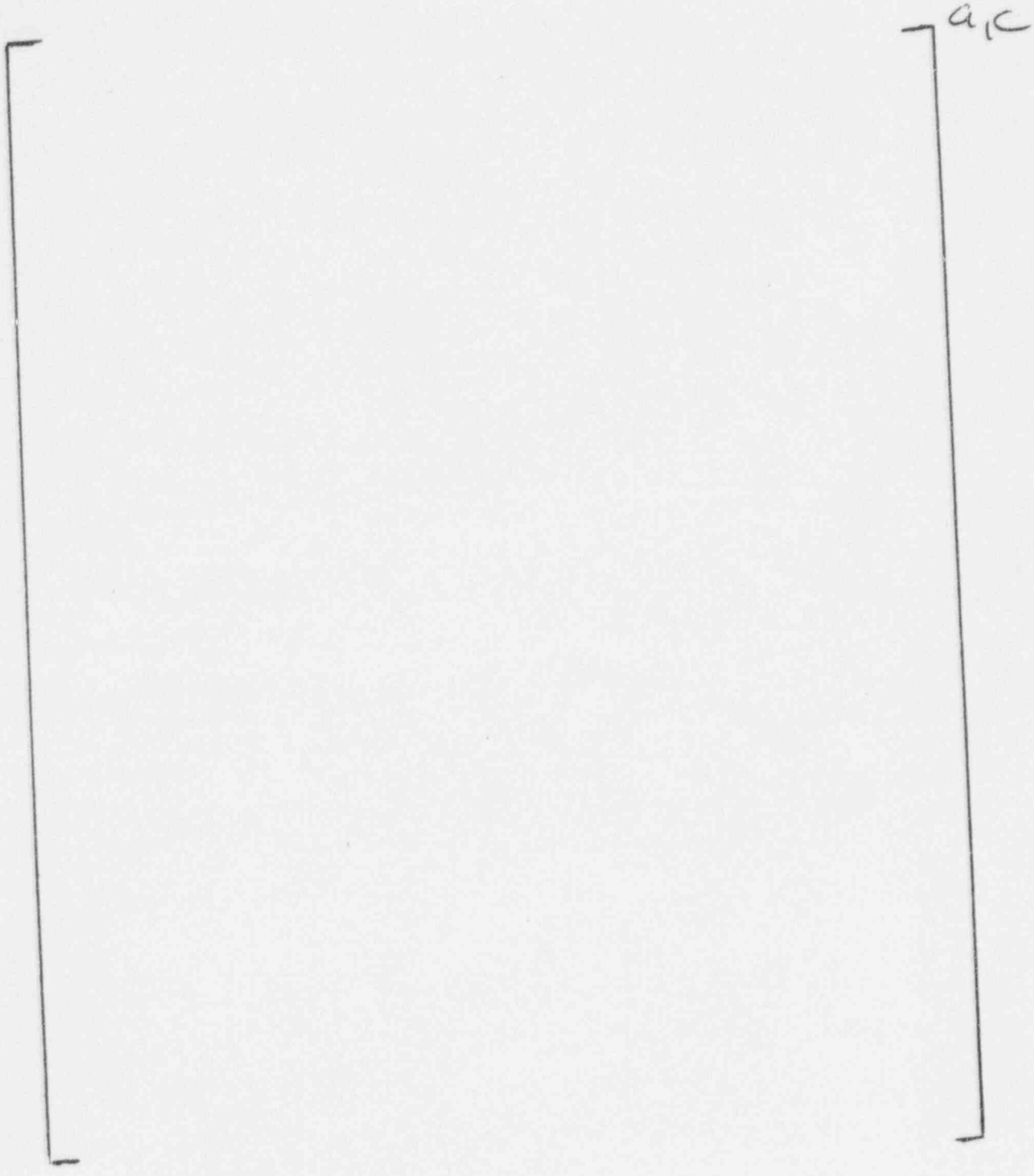
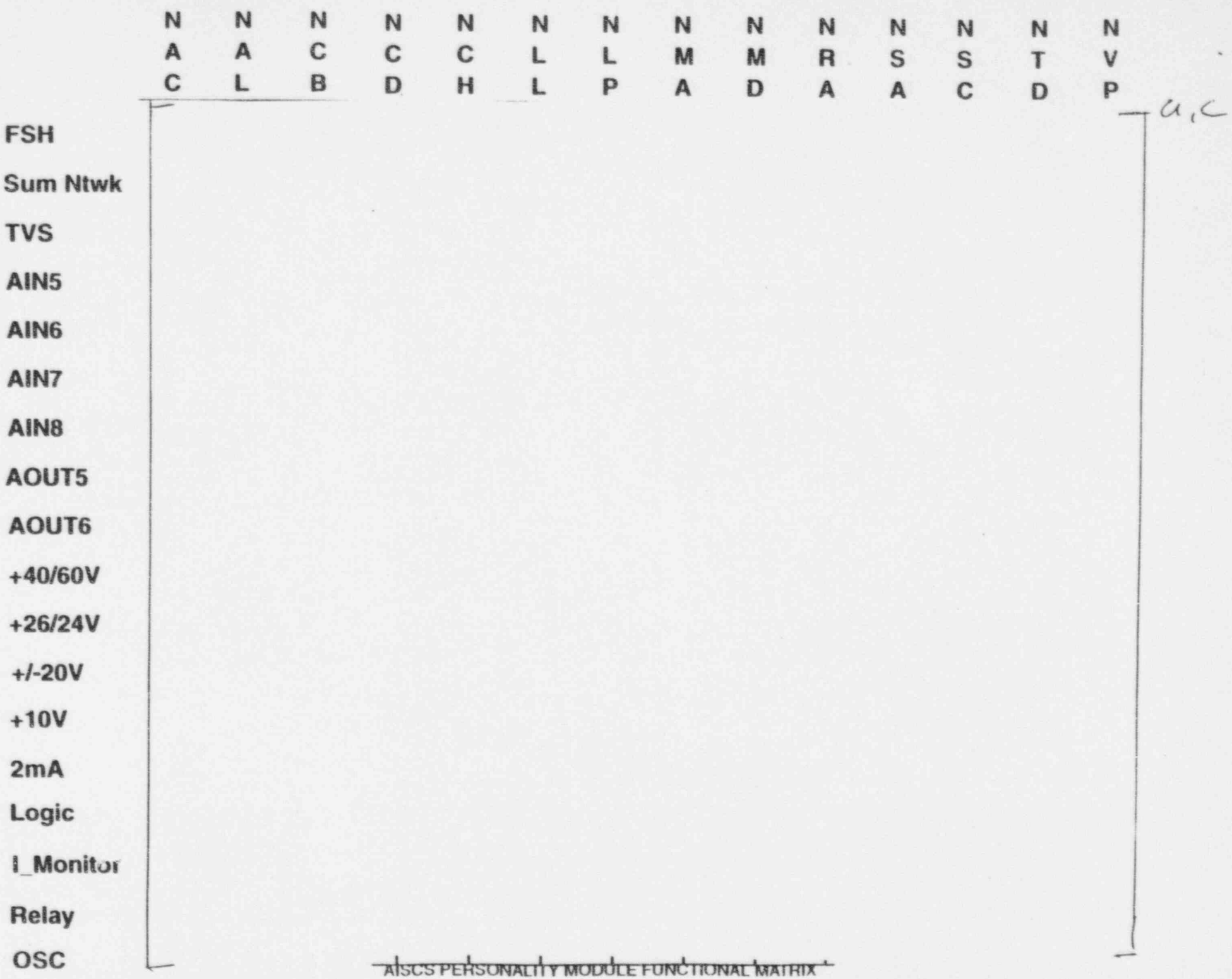


Figure 2-4 ASIC ALARM CIRCUIT LOGIC

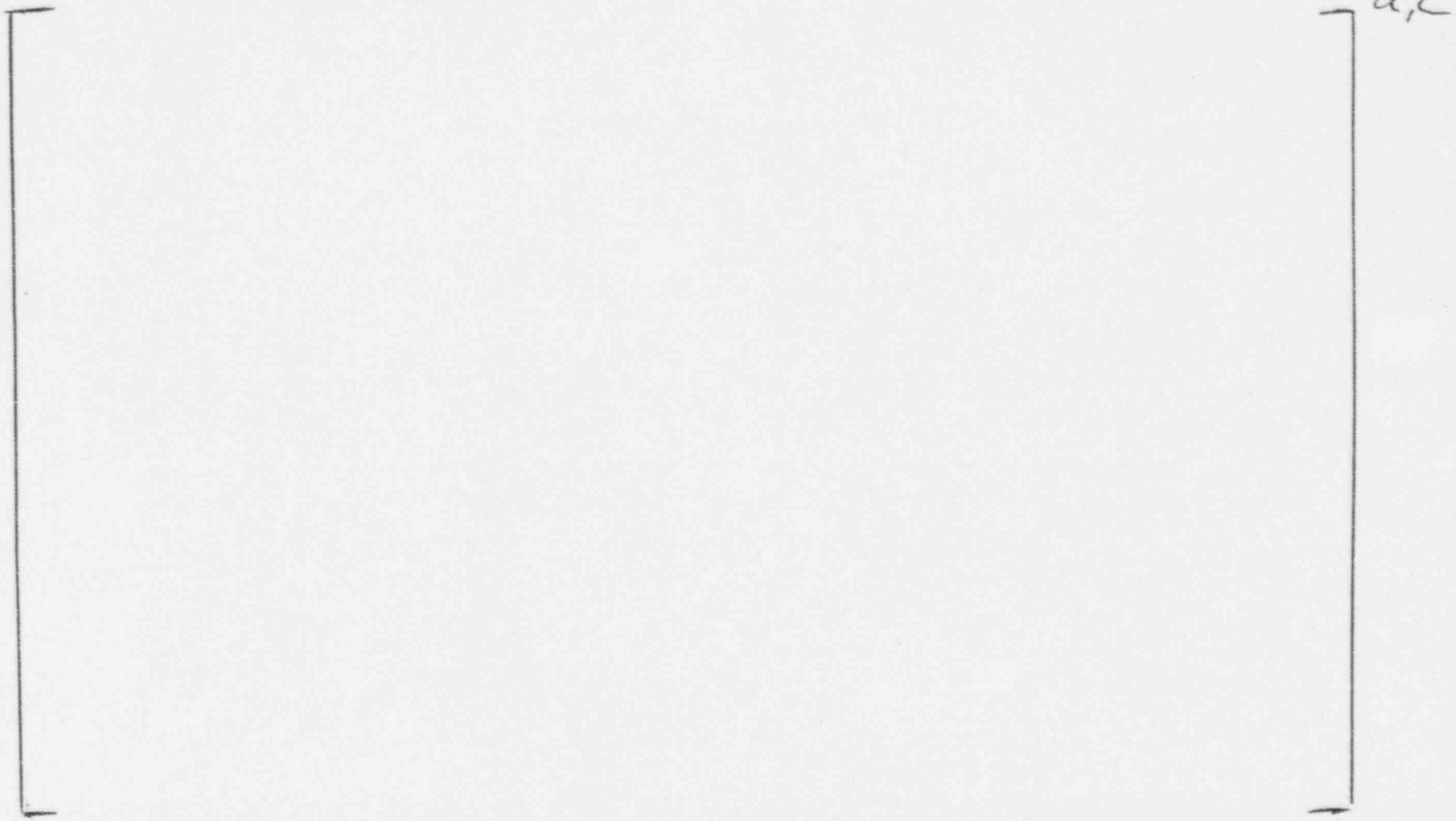

NACC
NALL
NCBB
NCCD
NCCH
NLLL
NLLP
NMMA
NMMD
NRRA
NSSA
NSSC
NTTD
NVVP
FSH
Sum Ntwk
TVS
AIN5
AIN6
AIN7
AIN8
AOUT5
AOUT6
+40/60V
+26/24V
+/-20V
+10V
2mA
Logic
I_Monitor
Relay
OSC
AISCS PERSONALITY MODULE FUNCTIONAL MATRIX

NCH PERSONALITY MODULE

NLL PERSONALITY MODULE

NMD PERSONALITY MODULE

TEST AND QUALIFICATION PROCESS



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ASICs TEST AND QUALIFICATION PROCESS

TEST AND QUALIFICATION PROCESS

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Licensing Strategy/Issues

Licensing Approach

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- WOG will submit Topical Report to the NRC via formal WOG letter.
- Topical Report will contain proprietary information and will be accompanied by an application for withholding and affidavit.
- Topical Report will be transmitted piecemeal by section.
- Key elements of submittal:
  - Test program results (component, card)
  - FMEA
  - EMI/RFI emissions/susceptibility
  - EQ program results
  - 10CFR50.59 evaluation
  - Regulatory criteria compliance

Schedule:

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■ Issue Letter on Intent to Submit Topical	1/97
■ Issue First Topical Report Section	3/97
■ Issue Final Topical Report Section	9/97
■ Issue Final Version of Topical Report	9/97
■ NRC Issues SER	11/97
■ South Texas Demonstration	11/97

- ◆ Plants Implement Replacement Cards Under One Time 10CFR50.59 (Equivalency Evaluation) and Treat As Spare Part.

Elements of Design Program that Support Licensing Under 10CFR50.59

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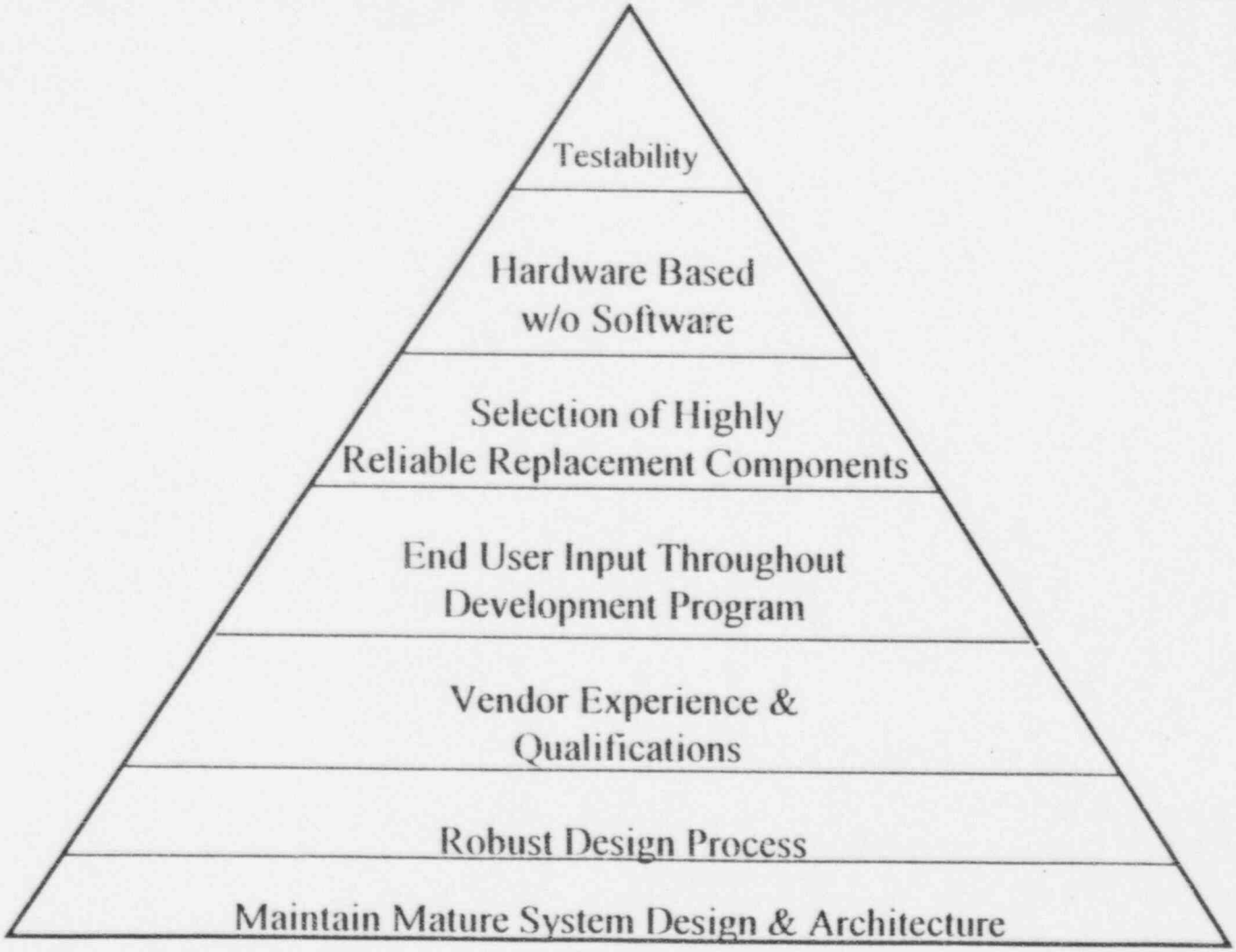

Maintain Mature System Design & Architecture

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- Replacement Design is Built on Proven System Performance
- System Design Basis is Well Known
- System Licensing Basis is Well Known
- ASIC-Based Card becomes Spare Part

Robustness and Integrity of the Design Process

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- The Robustness and Integrity of the ASIC Replacement Module Design Process Provides for Extremely High Confidence that the Performance Requirements have been Properly Translated to Data Flow Diagrams, Mnemonic Instructions have been Correctly Specified and Interpreted to Control Codes, and All Math and Process Functions have been Exhaustively Tested.
- Test Vectors were Developed Jointly Between Independent Organizations, ATC and ORNL. Tests were Applied to Actual Devices and the Results were Compared to Simulation Test Results.
- Example: ASIC Controller Design Process

ASIC CONTROLLER DESIGN PROCESS

Vendor Experience and Qualifications

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- Westinghouse is the Original NSSS Plant Designer, the OEM Supplier of the 7300 Process System, and an Appendix B Supplier with over Thirty Years of Design and Licensing Experience.
- ATC is a Supplier of Military Components Commonly Used in Safety Critical Applications. ATC has Extensive Experience in the Design and Application of Custom Integrated Circuit Technology.
- ORNL
  - National Lab
  - ASIC Experience includes Designs for Private Industry, Universities, European and U.S. Labs (Physics Experiments)
  - Developed Prototype under CRADA with EPRI
  - Process Control Experience

End User Input Solicited Throughout the Design Process

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- Hundreds of Man-Years Operating Experience and System Knowledge.
- Operator Interface Minimizes Impact on Plant Staff and Training.
- Utilities have Extensive Design Basis Knowledge.
- Close Utility-Vendor Relationship Provides for Successful and Stable Implementation.

Reliable Technology and Components

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- ASIC Chip Technology (1 micron) has Demonstrated Reliability on the Order of 1×10^{-7} Failures per Year.
- ASIC Mother Board Components Selected for a MTBF of 50,000 Hours.
- FPGA's Reliability Database Shows Failures on the Order of 1×10^{-7} Failures per Year.
- Components are Selected to have Higher Performance Specifications than Analog Board Components.

Hardware Based Solution

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- Hardware is Effectively Distinguished from Software when a Model can be Constructed for All Input/Output States, and a Device is Comprehensively Tested.
- The ASIC based replacement module does not contain software or programmable (modifiable) code.
- Each Control Code Enables a Specific Dedicated Math Circuit or Function in the ASIC.
  - The ASIC Circuits are not Programmable.
  - The ASIC Chip is a Dedicated Component.
- Controller Operation is Deterministic and Sequential, No Interrupts.
- The System Makes No Decisions on Input Data. There is No Branching or Alternate Signal Paths.
- The System Cannot Halt or Lock-Up.
- Failure of the Clock Circuit is Detectable and Results in an Alarm.

Simple and Testable Design

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- The ASIC Based Replacement Module is Pin-for-Pin Compatible With the Module it Replaces.
- No Internal Cabinet Wiring Changes are Required for the Card-for-Card Replacement Option.
- The ASIC Module Architecture Implements Standard Math Functions: Add, Subtract, Multiply, Divide, Square Root, Compare and Function Generator.
- Basic Math Functions are Standard, Simple, and Well Understood.
- Simple Math Functions can be thoroughly tested.
  - Simulation Tests are Performed at Each Design Stage, and are Repeated on the Fabricated ASIC.
  - The ASIC Design is Completely Testable at the Component Level (100% Fault Coverage).

Simple and Testable Design (Cont.)

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- A Controller PROM Will Enable the Standard Math Functions in the Correct Sequence to Perform Process Functions.
- In the ASIC Replacement Module Application, each Control Code has a Direct Correlation to a Unique Mnemonic Instruction. This Design Characteristic Allows for a 100% Validation Verification of the Controller Instructions to the ASIC Chip.
- Process Functions are Completely Verified and Tested.

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ASIC Replacement Module Regulatory Requirements Compliance

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REGULATORY REQUIREMENTS

- ACCEPTANCE CRITERIA
  - 10 CFR Part 50 - Domestic Licensing of Production and Utilization Facilities.
  - 10 CFR Part 50, Appendix A, General Design Criteria for Nuclear Power Plants.
  - 10 CFR Part 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.

- REGULATORY GUIDELINES
  - RG 1.22 Periodic Testing of Protection System Actuation Functions.
  - RG 1.47 Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems.
  - RG 1.53 Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems.

Regulatory Requirements (Cont.)

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- REGULATORY GUIDELINES (Cont.)
  - RG 1.62 Manual Initiation of Protection Actions.
  - RG 1.75 Physical Independence Of Electric Systems.
  - RG 1.97 Instrumentation for Light Water Cooled Nuclear Power Plants to Assess Plant Conditions.
  - RG 1.105 Instrument Spans and Setpoints.
  - RG 1.118 Periodic Testing of Electric Power and Protection Systems.
  - RG 1.151 Instrument Sensing Lines.
  - RG 1.152 Digital Computers in Safety Systems of Nuclear Power Plants.
  - RG 1.153 Power Instrumentation and Control Portions of Safety Systems.

Draft Regulatory Guidelines

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- The ASIC Replacement Module Application is Viewed as an Implementation of a Hardware (Completely Testable) Technology. As Such, the Draft Regulatory Guidelines on Software Used in Safety Systems are Not Directly Applicable. However, the Design Process for the ASIC Based Replacement Modules Exhibits Many Consistencies with the Software V&V and Development Processes Endorsed by DG-1054 and DG-1059.

- DG-1054 Verification, Validation, Reviews, and Audits for Digital Computer Software used in Safety Systems of Nuclear Power Plants.

  Endorses IEEE Std 1012-1986 and IEEE Std 1028-1988.

- DG-1055 Configuration Management Plans for Digital Computer Software used in Safety Systems of Nuclear Power Plants."

  Endorses IEEE Std 828-1990 and ANSI/IEEE Std 1042-1987.

- DG-1056 Software Test Documentation for Digital Computer Software used in Safety Systems of Nuclear Power Plants.

  Endorses ANSI/IEEE STD 829-1990.

Draft Regulatory Guidelines (Cont.)

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- DG-1057 — Software Unit Testing for Digital Computer Software used in Safety Systems of Nuclear Power Plants.

  Endorses ANSI/IEEE Std 1008-1987.

- DG-1058 — Software requirements Specifications for Digital Computer Software used in Safety Systems of Nuclear Power Plants."

  Endorses IEEE Std 830-1993.

- DG-1059 — Developing Software Lifecycle Processes for Digital Computer Software used in Safety Systems of Nuclear Pov.er Plants.

  Endorses IEEE Std 1074-1995.

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Identification & Discussion of Licensing Issues

Summary of NRC Concerns (as understood by WOG ASIC Steering Committee)

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- Thorough description of testing at all levels (3/96).
- Common mode failures at system level (3/96).
- Chip quality controls (3/96).
- Proper translation of 7300 requirements (3/96).
- V/V of software design and validation tools (3/96).
- Software issues applicability to ASIC chip (3/96).
- Power supply impacts effects of power quality (3/96).